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Dust Storms

Observations of peat dust storms were made throughout the calendar year 1959. The first recorded storm occurred on March 3, 1959 while the last one was on December 13, 1959. Fifty-five peat dust storms were recorded altogether (more than twice last year's total), ten of which by-passed Stockton and Lodi and were caused by more or less northerly winds. The highest total number recorded during the previous four-year period was in 1957 with 33 peat dust storms. Although, as explained earlier in this report (pp. 35 and 36), numbers and intensities of recorded dust storms are not necessarily directly comparable one year with another, it is the consensus of the general public and concurred in by the writer of this report that the year was at least as bad, from the dust standpoint, as any of the five years comprising this report and probably worse even than 1955, the most dusty year during the first four years of the project.

It is of interest to note that the least dusty year in the past five years (1958) had also the highest winter and spring rainfall (19.1 inches) while the dustiest year (1959) had the lowest winter and spring rainfall (8.7 inches). It cannot be implied from this, however, that dustiness can be directly related to total winter and spring rain. Timeliness of hard late spring showers and frequency and magnitude of high velocity winds are extremely important factors.

The following data for peat dust storms for 1959 are arranged in the same pattern as reports from previous years. The statements on pp. 35 and 36 of the 1956 report relative to definitions and changing standards from one year to another are applicable to this report.

Westerly dust storms hitting Stockton and/or Lodi:

Number of storms by month

	1959
January	0
February	0
March	0
April	3
May	17
June	11
July	7
August	5
September	2
October	0
November	0
December	0
Total	45

Number of storms by half-months for May and June

		1959
May	1-15	5
May	16-31	12
June	1-15	7
June	16-30	4

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Talley of storms by severity:

Number of storms by severity

	1959
Very severe	1
Severe	6
Moderate	7
Mild	16
Very mild	15

Severity by months, 1959:

Number of storms

	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.
Very severe			1					
Severe			2	4				
Moderate		1	2	2		2		
Mild		1	7	4	3	1		
Very mild		1	5	1	4	2	2	

Northerly dust storms generally by-passing Stockton and Lodi:

There were 10 storms in this category in 1959.

Storm category	Dates, 1959
Severe	5/6, 10/29, 12/13
Moderate	5/20, 10/30
Mild	3/3, 4/6, 5/11, 10/2
Very mild	3/10

Although October 29 is listed as the date of a severe dust storm by-passing Stockton and Lodi, the implication in this table is that there was little if any peat dust in Stockton (and Lodi). Actually there were large quantities of mineral dust not only from local sources such as unpaved streets, school playgrounds and athletic fields, and subdivision construction, but also from mineral soil farmland to the north.

In the 1957 report on pages 65 and 66 and the 1958 report on page 95 were listed the distribution of dust storms throughout the various years. The striking point of the comparisons was that even though the years varied greatly in total dustiness and rainfall pattern, the distribution of storms throughout the year remained very similar. The following data shows that 1959 had

essentially the same pattern as the previous four years.

Distribution statistics (westerly storms)

Per cent of storms (all categories) in each month:

	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.
1959	0	7	38	24	16	11	4	0
5-year ave.	1	7	29	34	13	11	4	1

Although the percent storms for May is high and for June is lower in 1959 than the long-time average, the sum for the two months is almost identical (62% for 1959; 63% for 5-year average). In addition, since the majority of May storms occurred after the middle of the month, the percentages of the year's storms in 1959 that occurred in the period May 15 - June 30 (see page 66 for information on past seasons) were nearly identical with averages of past years. For westerly storms hitting Stockton and/or Lodi in 1959, 51% occurred in the period May 15 to June 30. Of the bad westerly storms occurring during the year (moderate, severe, very severe) 64% occurred during the period.

The pattern of northerly storms for 1959 was similar to the aggregate of past years although this pattern is not as well developed as the westerly storms, partly because there are so few northerly storms each year. Generally the northerly storms occur in the months of March, April and May (as they did this year) and in late fall or early winter. With respect to northerly storms, 1959 differed mostly in total number of such storms, particularly in the fall and winter months. This year there were three bad storms during this period, three times as many as any previous year covered by this project.

Detailed descriptions of most of the dust storms were made. This information was used in judging dust storm intensity and parts of it are to be used by the Bureau of Air Sanitation, State Department of Public Health in correlation work in conjunction with dust and smoke sampling done by the San Joaquin Local Health District. It is also to be used in connection with aerial dust storm reconnaissance carried out by the San Joaquin County District Attorney.

Dust storm correlation with wind velocity.

Experience and observation since 1955 indicated that dust storms were generally caused by wind velocities of about 15 mph (hourly average measured at 6' height) and greater. The question arose as to just how well dust storms and dust storm intensities are correlated with wind velocity, and what wind velocities are associated with dust storms of various intensities.

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As a preliminary step in understanding these relationships, all storms from 1955 through 1958 inclusive for which there was wind data were listed. Wind data was taken primarily from the Ridge Tract spot climate recorder with some data from the Terminous recorder in 1958 when Ridge data were incomplete. Maximum velocities were the highest hourly average for the day in question. The maximum wind velocities associated with each storm, by intensity category, were then tabulated. Below are the condensed results.

Maximum wind velocity associated with dust storms 1955-1958

	V. Mild	Mild	Moderate	Severe	V. Severe
No. of storms investigated	22	33	17	10	2
Ave. of max. velocities, mph	14.4	16.2	16.8	16.4	17.6
Range of max. velocities, mph	7.5-18.4	11.9-25.4	13.8-22.5	10.5-19.3	15.8-19.5

Although average maximum velocities appear to have a rather orderly trend upward with increasing storm intensities, the wide range of velocities causing a storm of any given intensity indicates there are other potent factors beside maximum wind velocity. One factor considered, and then determined to be of minor importance, was the use of some form of total hours of high windiness per day or some function of velocity hours. Examination of the wind velocity and dust storm description data indicated that almost invariably, the higher the wind velocity, the higher the total number of hours of dust causing wind velocities. Only twice, for instance, did days occur where a one or two hour high velocity period would be injected into an otherwise calm day.

Examination of the basic data brought out two other important factors, however. First of all, it appeared that the wind velocity needed to cause a dust storm of a given intensity diminished as the season progressed. This appeared reasonable since the soils dry out as the season progresses and continued cultivation progressively breaks down the aggregation of the soil. It also appeared that winds with a southerly component (WSW or SW) as measured at Ridge Tract had less velocity for a dust storm of given intensity than westerly winds without the component.

On the basis of the above observations, tabulation of the basic data was then made by pairs of months and leaving out storms associated with winds containing a southerly component as measured at Ridge Tract. This tabulation follows:

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Maximum wind velocity in MPH associated with dust storms 1955-1958. Storms with winds with southerly components excluded.

	V. Mild	Mild	Moderate	Severe	V. Severe
March and April	15.3 (14.3-16.5)	17.3 (16.5-18)	20.3 (18.8-22.5)		
May and June	15.6 (13.7-18.4)	17.2 (11.9-25.4)	16.6 (1[illegible].0-18.0)	18.4 (17.3-19.3)	19.5 (19.5)
July and August	12.0 (10.5-13.4)	14.4 (13.4-15.4)	12.7 (12.7)		
Southerly component wind only:					
May and June	15.6 (15.2-15.9)	16.0 (13.8-17.4)	15.2 (14.8-15.7)	16.0 (13.5-19.3)	15.8 (15.8)

This separation of variables has considerably reduced the spread of velocities (a notable exception being mild storms in May and June) associated with any given storm intensity. It also demonstrates clearly the increase in storm intensity with small increases in wind velocity. A reduction of wind velocity of all winds by 10% to 15% would materially lessen the number and severity of dust storms and a reduction of all winds by 25% would eliminate all but a few relatively mild storms. These figures should be of value in the design of wind reducing features such as windbreaks.

One factor not considered in this study which probably accounts for the rather high variability in the May-June column is the occurrence, particularly during May, of brief, heavy rain showers. Very strong winds may follow such storms but the rain will cause an erosion resistant crust on the soil which will last one or two weeks or more.

Two other factors which no doubt cause some of the spread in velocity figures for a given storm intensity as well as apparent anomalies (such as a moderate storm with 12.7 mph) have to do with characteristics of the wind itself. Gustiness has not been measured in these studies but it would appear (because of the higher maximum velocities) that of two winds with the same average velocity, the gustier would create the most dust.

The other wind factor has to do with the locations within the delta where the wind is measured. A spot climate recorder was located on Bacon Island, 15 miles west of Stockton, for the first time this year. Spot checking of the data revealed a number of days when winds at Terminous were only 10 to 14 mph but were 15 to 17 mph on Bacon Island. A more complete study of this phase must await more data.

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Wind Variability

A number of public agencies in San Joaquin County have become concerned with methods and techniques for describing and measuring wind velocity. One question that came up was the short time variability of wind velocity and what would be a proper interval for measuring average wind velocity. To shed some light on this question a precision cup-type integrating anemometer was observed in a north wind at Davis in the fall. Accumulated wind passage was read from the dials at intervals as short as 15 seconds for a period of 1 hour. Wind velocity averages were then calculated for each of the 15 sec., 1 min., 5 min., 15 min., and 30 minute intervals in the hour. Velocities using 1 minute intervals varied from 4.5 mph to 16.5 mph. Below is the table of calculated velocities based on intervals of 5 minutes and greater.

Wind velocity averages calculated on wind passage for different intervals of the hour. To nearest 0.5 MPH.

5 minute	15 minute	30 minute	1 hour
1 .5			
12	11		
9.5		11	
10.5			
13	11		
9.5			11.5
13			
9.5	12		
13		12	
12			
11.5	12		
13			

It should be noted that any consecutive group of three 5-minute intervals gives essentially the same results as the particular grouping shown above. For the particular wind studied, a 15-minute period would be a very reasonable averaging interval. A 5-minute interval could result in an error as great as 15% from the general wind velocity. This 15-minute averaging period applies to this particular north wind in the fall and perhaps to other fall north winds. Whether it applies also to turbulent westerly winds coming across bare peat soil in spring and summer is not known with certainty. Similar experiments to the one just described would be valuable.

To illustrate the characteristics of continuous reading indicating anemometers and to demonstrate the high variabilities of wind velocity over short intervals an experiment using a Westach continuous reading cup type anemometer was undertaken. For two consecutive 3-minute intervals during a northerly wind in the fall in Stockton, velocity indications were recorded one after the other, as fast as possible. The condensed results are shown onnext page.

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First 3-minute interval:

Maximum MPH - 9

Minimum MPH - 1

83% of readings were 6 MPH or less

Second 3-minute interval:

Maximum MPH - 15

Minimum MPH - .4

55% of readings were 8 MPH or more

It is apparent that this type of anemometer is of little value in characterizing the wind velocity except as to maxima and minima.

Inter-Row Planting Experiments

The principal work in the 1959 season concerned field scale inter-row planting of white asparagus in three different locations in the delta and a continuation of variety-time of planting experiments in order to determine the most suitable plants for inter-row purposes. Observations were also made on strip planting of barley in winter spinach for the purpose of stopping damaging soil erosion due to strong north winds. Information was also obtained on the results of private experimentation with inter-row planting on 6' row width asparagus.

As was noted in last year's report (page 96) the program for 1958 was hampered by the abnormally heavy spring rains. This was particularly true with respect to evaluation of inter-row planting by dust sampling. As a result, dust collection work was continued in 1959 although this was somewhat hampered by the lateness of one planting (Way 6) and failure of another to grow.

The successful variety-time of planting plots during the 1958 season eliminated a number of plants from further consideration and suggested the possible value of certain untried plants and combinations. Variety-time of planting plots were again instituted in 1959, not only to test the suggested new varieties and combinations but also to test the promising plants in another season. 1958 being an extremely wet year and 1959 being a very dry year, it was possible to observe the plants under the extremes of conditions likely to be encountered.

Variety-time of planting observation plots. The plots were planted and observed in a manner similar to the 1958 plots. The main difference being that duplicate plots were set up on different islands under different soil conditions. In addition a wheat variety trial of the Agricultural Extension Service on a third island was also observed. One of the sets of plots was at Camp 5, Bridge Tract, where normal moisture conditions prevailed. The other set was at the north end of Bacon Island where the soil had been tilled deeply until

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it was loose and fluffy and with poor to occasionally moderate moisture so deep that furrowing out was necessary before planting.

Although the growth in the Bacon Island plot was in general much poorer than the Ridge Tract plots, the better portions compared favorably. It was judged that the variability and general unthriftiness in the Bacon Island plots was due primarily to a low moisture condition. It was felt, however, that furrowed out asparagus centers at any reasonable planting date would normally, even in dry years, have more moisture than these Bacon Island plots. For this reason, the growth figures given below for the various varieties are based on the Ridge plots and the better portions of the Bacon plots.

Six plantings were made in the period March 19 to May 6 inclusive. Weeds were controlled by 2,4-D spray or hand weeding depending on the growth stage and sensitivity to 2,4-D of the plot to be weeded and adjacent plots. Notations were made throughout the growing season as to height, stiffness, leafiness, state of maturity, greenness, yellow dwarf infection, and any other characteristics concerned with its suitability as an inter-row plant for asparagus. No fertilizers were used.

As in the previous year, both tall-growing plants and small winter grains were used. Several varieties of male sterile hybrids were also tried in an attempt to find a suitable non-volunteering plant. An early planting, set out in mid February and first of March to test the early season use of fava beans and other varieties to protect green asparagus against erosion caused crooks failed primarily due to a large local bird population at the plot site.

The barleys. California Mariout, Arivat, and Rojo were tested. Unlike the 1958 season, in 1959 the barleys suffered negligible damage from yellow dwarf. Although, in general, California Mariout tended to be faster growing in the early stages and leafier and more dense than either Arivat or Rojo, the latter two varieties have the advantage of attaining a final height of 4" to 8" taller. As has been shown earlier in this report, dust storm rate increases rapidly in mid May. For most effective results, therefore, it is desirable that inter-row plants be of adequate height, density and stiffness for at least some wind control by this time. All the barleys planted mid March and first of April had these properties but when planted mid April were either not yet suitable or only just beginning to be. The barleys planted mid April did not become generally suitable for dust control in asparagus until the beginning of the third week in May and those planted April 22 were not adequate until the end of May - at which time one-third of the worst dust storm period had already passed. Rojo and Arivat had generally the same characteristics with Rojo generally the superior of the two. Whether Rojo and Arivat were superior or inferior to California Mariout (considered to be the standard of comparison to date) depended on the date of planting and date of observation. The early plantings of Arivat and Rojo proved superior to California Mariout because they were of adequate height, density and stiffness (though perhaps only equal to or slightly inferior to California Mariout) by mid May and continued to advance over California Mariout through adequate stiffness and density and superior height. They also remained green longer, a desirable characteristic. However, when planted from mid April to the first of May, California Mariout was superior to the other two during May because of its early fast growing and leafy characteristics. In common with the 1958 season, in 1959 Arivat and Rojo reached mature heights of 30"-33" while the California Mariout attained 24"-27".

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The oats and wheats. These are lumped together for the purpose of discussion because of their similar properties and the fact that only one oat variety and two wheat varieties emerged from the 1958 tests as suitable for further testing. Those tested were Swedish oats (from Idaho), Onas 53 wheat, and Sentry wheat. Growth rates and heights attained were closely similar to the 1958 trials. These varieties, because of their slow growing characteristics were one to two weeks later than the barleys in attaining adequate height, density, and stiffness for inter-row planting. On the other hand, the extra height and leafiness at maturity of these varieties over the barleys made them superior in the latter part of the asparagus season. For example, on May 23 oats and wheats planted mid March were all superior to the barleys planted at that time. However, the wheats and oats were only about equal to the tall growing barleys Arivat and Rojo (but superior to California Mariout) when planting date was first of April. With mid April planting, all barleys were distinctly superior to the oats and wheats when judged May 23. From observations made in mid June it was found that oats and wheats were superior to Rojo and Arivat only when planting dates were mid April or earlier.

Although somewhat slower to start, Swedish oats were considerably superior later (due to taller growth habit and upright extremely leafy stature) to Onas 53 or Sentry wheat. Sentry, although attaining the same stature as Swedish oats, was much less dense and leafy. Onas 53 wheat, although considerably shorter in height than Swedish oats (28"-30" as against 36"-40" at end of June for an April 22 planting), was far more leafy and dense than Sentry wheat. It does not appear from the results of the 1958 and 1959 plots that these oats and wheat varieties have anything to recommend them over the better barleys as single variety inter-row plants unless they are planted not later than the last of March. In this case they may be inferior to the best of the barleys during the first two or three weeks of May but somewhat superior there after. Their possible value in a seed mix will be discussed later.

Barley rate trial. A test was conducted to determine if there was any difference in growth rate or stature, particularly under low moisture conditions, if barley is crowded into a single drilled row instead of being spread out over 2 or 3 rows with 6" spacing. California Mariout barley was used and planted and observed at the same times as other grains in the variety plots. The planter was adjusted in each case to deliver the same amount of seed per linear foot of strip regardless of whether the strip consisted of 1, 2, or 3 drilled rows. Rates up to 10 lbs. seed per acre, based on asparagus acre with 8' row spacing were used. In no case was there any noticeable difference in height or leafiness among plots of same linear rate of seeding but different number of rows per strip.

Barley-oats mix. Observations during the 1958 season suggested that perhaps a mixture of seed, say barley and oats, might have merit. It was reasoned that such a mix might have the desirable rapid early growth characteristics of barley and the tall, leafy, late maturing properties of Swedish oats. This idea was tried in 1959 using California Mariout barley and Swedish oats in a 50-50 mix by volume. Again, planting dates and observations were the same as for other varieties. The results of this experiment were very gratifying and the principle of seed mixing for improving inter-row plant characteristics

appears promising. Until the middle of May, the mix had characteristics which were intermediate between the California Mariout and oats and sometimes better than the other barleys and wheats. By the last week in May, March planted mix was as good or better than the best of the two components. At this date, mid and late April planted mix was inferior to California Mariout alone but superior to all other varieties. In the latter part of May the mix seemed generally to combine the best features of the two components but not always to the extent of being equal to 100% of the best of the two. It was found that the barley helped give support to the leafy oats in the early stages. By mid June the mix had more the characteristics of the tall oats than the shorter barley. The 50-50 ratio of seed appeared to be about right.

It would appear that any mix should contain California Mariout barley for its early rapid growth and leafiness characteristics. Other taller but slower growing winter grains would probably be suitable. The particular choice would depend somewhat on date of planting. On the basis of the 1959 plots, Rojo or Arivat - Rojo preferred - would be used with California Mariout with plantings during the last week in April and later. Mid April plantings could utilize Sentry or Onas 53 wheats, Rojo or Arivat barleys, or Swedish oats along with the California Mariout. Of the five, Onas, Rojo, and Swedish would be preferred. Plantings prior to April 1st could make best use of Onas 53 wheat (preferred), Swedish oats or Sentry wheat in conjunction with the California Mariout. Although no stratification of oats and barley seed took place in the Planet Jr. planter, it is not known whether this would be a problem with seeds of such different size and shape as wheat and barley in a field scale planting operation.

Male sterile grains. In an effort to find some plant which would not go to seed under inter-row planting conditions and therefore eliminate any volunteer problem the following winter, four varieties of male sterile grains were obtained from Texas. Three varieties were sorghum A-lines, the fourth was a grain-grass hybrid. These plants proved to be wholly unsatisfactory due to their slow growth rate and spreading growth characteristics.

Sudangrass. In the 1958 trials sudangrass grew to be adequately tall for inter-row planting purposes but too high (6'-6½') by the end of the asparagus season for normal every-row inter-row planting. Sudan 23 was planted again in 1959 to test it in another season. This variety must reach at least 3' before it is adequately stiff and dense to be of much value for inter-row planting. The March plantings did not reach this stage until the first week in June. All plantings reached 4' to 6½' by the end of June, having grown rapidly during the hot June days. The problem with sudangrass is that its initial growth is too slow but its final height (by June 30) is unwieldy if not impossible to manage.

Sunflower. As recommended in 1958, only Grey Stripe sunflower was tested in the 1959 series. Growth rates and other characteristics were nearly identical with the 1958 season. Remarks made in the 1958 report (p. 100) are fully applicable to this year's planting. Although sunflower appeared to be a better windbreak than corn (see below), it has the disadvantage of not being able to use 2,4-D for weed control should that prove necessary. By the end of June, the sunflower was 6½'-7½' tall when planted mid March and 5'-5½' when planted May 6.

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Corn. Kings Cross KS6 was the variety tested in the 1959 trials. Its growth rate up to mid June was the same as last year's test with the King Phillip variety. By the end of June, March 31 planted corn reached 5'-6' height whereas the King Phillip in 1958 reached 6½'x7½' in the same period. These two varieties should be tested together in another season. Corn, like sunflower might have some usefulness in annual windbreaks, particularly where protection is needed after mid June.

Ryer 15. Ryer 15 did not do well in the 1959 plots and reached a maximum height (29"-38") of 10" less than in the previous year. Throughout the season Ryer 15 was inferior to barley, oats, and wheat in growth rate and density. By the last week in May, Ryer planted as early as mid March was only 15"-18" high and of unsuitable density and growth characteristics.

Kenaf. Kenaf is a subtropical fiber plant and normally grows to a height of 10'-12'. It was tested to determine its usefulness for a tall growing, wide spaced inter-row plant. Planted in mid February and first of March, it failed to germinate. With planting dates of mid April and later, germination was satisfactory but growth rate was very slow. By the end of June mid April planted Kenaf was 22"-26" high on Ridge Tract, slightly taller on Bacon. By fall, the plants were 8'-10' high and bore a striking resemblance to common hemp or marihuana (Cannabis sativa L.) with which they could easily be confused.

Wheat variety trials. A wheat variety trial set out by the Agricultural Extension Service on Staten Island in January was observed in June. All varieties were completely dry and mature. The varieties observed were Pacific Bluestem, Big Club 43, Onas 53, Baart 46, Ramona 50, White Federation 54, Poso 48, Sentry, Mindun, and Vernum. They were judged on mature height and tendency to lodge. Of the ten varieties only three were sufficiently tall and upright to warrant further trials for inter-row planting purposes. They are Pacific Bluestem, Big Club 43 and Onas 53.

Of the varieties tested or observed above, only nine warrant further testing. These varieties are: California Mariout, Arivat, and Rojo barleys; Onas 53, Pacific Bluestem, and Big Club 43 wheats; Swedish oats; King Phillip and Kings Cross KS6 corns. Further trials should be conducted with barley-barley, barley-oats, and barley-wheat mixes. Grey Stripe sunflower should be kept in mind for use as special purpose annual windbreak.

Field scale inter-row planting. Unlike the 1958 season, which was extremely wet, the 1959 season was marked for its low rainfall - one of the driest in recent years. In addition, ridging for white asparagus production took place fairly late. As a result, two of the cooperators, who inter-row planted after ridging up for white asparagus, were unable to plant until the end of the first week of May. The third cooperator interplanted into green asparagus before ridging for white and was able to interplant in mid April.

No interplantings in early market asparagus for protection against crooks was attempted in 1959.

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Plantings by two of the cooperators were essentially parallel to the prevailing winds (with the exception of a 10-acre field at right angles). Plantings of the third cooperator were on long, narrow fields at 15° - 30° to the prevailing wind. Visual observations of effectiveness were hampered in this case because dust blowing across from one field to another made critical observation difficult.

In all cases, adjoining asparagus fields, similar in nature to the inter-planted field were left non-interplanted as controls.

Table of plantings:

Island	Acres	Row Spacing	Grain	How Planted	Date Planted	Effective
Terminous	347	8'	Arivat	Drilled-3 rows 6" spacing	4/12-4/17	250 acres
Ridge	53	8'	Calif. Mariout	Drilled-1 row	5/6,7	Only late June
McDonald	27	7'	Barley	Drilled-1 row	5/9	No

The following numbered paragraphs list the more pertinent management facts and observations obtained from the 1959 inter-row planting program.

1) Too late to be included in the 1958 report was information obtained in the winter of 1958-1959 relative to the volunteering of 1958 field scale interplantings. At Terminous, only very slight barley volunteering was found in January which was deemed no problem and no extra diskings or other cultivation were required to control it. Likewise on Ridge Tract, there was no problem with volunteering grain.

2) Three types of planters were used, all successful. They had all been used in previous years. All used standard grain distributors and single or double disk openers. One drill was a standard 10' grain drill with appropriate openers removed and tubes stopped up. It had the advantage over the other two in not requiring a tool bar tractor to tow it. Another type was a standard 3' tricycle-type horse drawn grain drill modified for tractor use and narrower planting width. The third type was specially designed and built for inter-row planting. Each of the pair was rear tool bar mounted with a gauge wheel in back. Grain box and distributor, openers, and drive mechanism were from an old salvaged grain drill.

3) Through lack of care, the planters used on one of the islands with 8' row spacing were set at 7' 2" spacing center to center. It is fortunate that no barley was lost in the re-ridging process. If the drilled rows had not been very straight, if three rows per strip had been used instead of one, or if the beds had required more dirt in the re-ridging process, some to considerable amounts of barley would have been lost in the re-ridging process. This would have resulted not only in trashy beds but loss of inter-row effectiveness.

4) Some of the inter-row plantings on another island were not so fortunate. In this case, strips of three rows each, 6" spacing were drilled into green asparagus beds prior to ridging for white asparagus production without prior furrowing out. Ridging and re-ridging operations eliminated all but one of the three drilled rows over much of the area. Although the inter-plantings lost some of their effectiveness, a fairly high rate of seeding (16# per asparagus acre) held the loss to a minimum. The evidence for single, or at most double drilled rows, especially when planting occurs prior to ridging for white, appears so strong as to effectively rule out from consideration any further three row planting.

5) The most effective inter-row planting in 1959 was planted in mid April despite the fact that ridging for white had not occurred. Ridging these 8' beds for white asparagus was completely successful although some loss of inter-row occurred (see par. 4 above). In other fields planted at the end of the first week in May after ridging and center working operations were completed, barley inter-row either failed completely or did not attain a satisfactory height and stature before the middle of June. It is clear that if at all possible planting should be done no later than April 15 even if it means planting into green asparagus. Proper furrowing out of the centers should make this latter process more feasible.

6) A slight problem which has always existed with inter-row planting is the ridge on which the inter-row strip is left standing after a ridging or re-ridging operation. Without inter-row planting, this ridge is normally knocked down by working the centers, thereby leaving a flat center between ridges on which the harvesters walk. This is not possible in the presence of inter-row planting. Adequate furrowing out prior to planting would not only minimize this inconvenient ridge, it should also make the initial ridging operation easier to do when the inter-row is planted into green asparagus.

7) Over one hundred acres of green asparagus planted inter-row were lost in a severe dust storm. It was then too late to replant. Planted April 16-17 and suffering some damage in the splitting operation prior to ridging for white (perhaps because of lack of moisture in the soil), the rather poor barley was wiped out by the drying winds and soil erosion of the very severe dust storm of May 12. It has always been realized that this is the chance that the user of inter-row planting must live with. The chance of loss such as this from a windstorm appears slight however and other inter-row plantings at various stages of growth suffered little if any from the storm.

8) Although the field of inter-row planting with 7' row spacing failed from low moisture and late planting, it is not known whether planting into green asparagus prior to white ridging is feasible on this narrow a row spacing, even with furrowing out. Prior successful interplantings in 7' beds have been done after white ridging on soils that will hold a high, steep sided ridge. The soil in the field interplanted this year was light making it impossible to form a high ridge with wide, flat centers.

9) None of the inter-row plantings constituted a fire hazard of any sort by the end of the asparagus season.

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10) A proper evaluation of the volunteering problem from 1959 inter-row must await observations in the winter and spring of 1960. By December 1959 barley volunteer, never heavy, was all but eliminated by normal field diskings by one cooperator, one after a hard September rain to eliminate weeds and another after corn chopping in the fall. Neither of these operations were done by the cooperator on the second island and volunteering there was slight to moderate in density and up as high as 16"-23" in clumps.

11) One grower, in private experimentation, tried several techniques and several plants for inter-row planting of 6' beds ridged to white asparagus. He was unable to plant and maintain a stand through the re-ridging procedures because of the physical lack of space and soil.

12) Inter-row planting of spinach was tried again this year, (see par. 9, p. 104 of 1958 report). The space between barley rows was shortened from 28 yards to 21 yards and the barley was planted earlier. On January 29, the barley was 8"-11" tall and the spinach was just up one inch. No wind storm occurred at this critical time to test the effectiveness of the barley strips. On March 3 when the barley was 10"-12" high and spinach was 2", an extremely strong north wind came up. Some, but not all bare fields in the district, were blowing dust. No dust came off the spinach. Although it was dry and had been cultivated, the surface was rather coarse granular instead of loose, smooth. It is doubtful that wind erosion would have taken place even if the inter-row barley had not been there.

Wind erosion evaluation. Evaluation by observation and by impinger-type collectors as described in last year's report was continued this year. The need for adequate controls as pointed out in last year's report was again emphasized this year. Although adequate controls are essential to the accurate measurement of dust prevention ability of inter-row planting, such controls are not always obtainable in field experimentation of this type. The value of dust collection measurements in the best inter-row planting (that planted mid April) was nullified when the proper field for a control was not left unplanted. The interplanted field matching the field left unplanted was found to have a "heavy" streak in it and therefore less erodable than the control. Dust collections indicating a very high degree of success had to be considered invalid.

From the standpoint of controls for dust collection measurements, the Ridge Tract fields were far superior to the Terminous fields mentioned above. Unfortunately the quality of inter-row planting was rather poor due to the late planting date. The dust collections were made from June 10 to June 26 during which time the barley grew from 12"-14" to 13"-15½". These heights are considered almost minimal for any reasonable degree of protection. Inter-row planted at an earlier date would have been up 25" to 35" or more depending on variety; in which case, a much greater reduction in dust could have been expected. In the period cited, nineteen individual collections were made from five different "set-outs". Dust collectors were left in the field 2 to 5 days per "set-out" and collected dust from one or more storms. The percentages below are calculated from the averages of each collection period. The percentage

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column shows the percentage of dust from the inter-row fields compared to the control fields.

Inter-row effectiveness, Rindge 1959

Dust collection period	Dust from interplanting as fraction of control
6/8 - 6/10	65%
6/10 - 6/15	40%
6/15 - 6/18	72%
6/18 - 6/23	79%
6/23 - 6/26	42%

The variability of efficiency shown above probably stems from both differences in wind direction and velocity although the wind generally was at an angle of 15° to 30° to the plots.

Observation of the Rindge Tract fields during a dust storm were inconclusive since dust blowing across from one field to another made observation difficult as to just where the dust was originating. It appeared, however, that inter-row was effective in lessening the dust.

After the severe storm on June 25, the control fields on Rindge were obviously much more eroded by the storm than the inter-rowed fields. The control fields had more drifts, more leveling of centers, greater loss of bed height and the bed shape was far more changed to a low, flat, sharp peaked shape.

Although there was no adequate internal control in the Terminous interplantings, it was obvious that the fields would have been much more dusty without the interplantings.

One-sheet answer. A "one-sheet answer" was produced as a guide to any growers desiring to put in inter-row planting. Published in April, it condensed the experience gained in this project over the four previous years. It is attached on the next page as a part of this report.

Windbreaks

Bamboo. The prospects of using bamboo for windbreaks in the delta are discouraging. As was noted in last year's report a hard frost in November 1958 severely damaged the foliage of the test planting. Observation during 1959 indicated that most of the above-ground culms and branches were also killed. The plants "came back" partly through new leaves on some of the undamaged branches but mostly from small shoots from the ground at the base of the plant. No tall culms were produced and the 1959 height of the plants was approximately half of the 1958 height.

A new planting at the site of the above planting was attempted. Stock was obtained from a planting at Correia Ferry in the delta which was believed to be Phyllostachys bambusoides. Most of the material was one year

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old rhizomes, although a little was current season stock. It was collected February 23 and planted February 27-28. Seventeen plants had emerged by May 15 but they died through desiccation due to inability of cooperator to get water to them.

The results of the 1958 rhizome cutting experiment were observed. No excised rhizomes whether left in place or replanted threw any culms in 1959. This is probably due to desiccation in the dry top layers of soil in which they are normally found. This would indicate that cutting rhizomes in the fall by disk or chisel would effectively contain the bamboo and prevent its spread into the cropping area.

Other windbreak material. Arizona Cypress. As mentioned in 1958, this tree appeared unsuitable as a Christmas tree but might have some value as a windbreak tree. Little change or growth has taken place in the past year. The maximum height for this variety under these conditions appears to be 12'-14'. Where a windbreak of this height is desirable, this might be a suitable tree. Its growth and characteristics will continue to be followed.

Poplar. A poplar windbreak was again observed to decrease in density to 25%-35% during a hard wind. Measurements showed an average tree spacing of 5' and a height of 55'. It is planned that this windbreak will be studied in the spring of 1960 by means of recording anemometers.

Casurina (horsetail beefwood). Casurina has been planted by a cooperator to observe its potential usefulness as windbreak material. It is growing rapidly but seems to be 2,4-D sensitive.

Snow fence. Snow fencing was studied this year by means of anemometers. The results appear in a later section.

New Crop Possibilities

As has been mentioned in previous reports, these are joint projects with the Agricultural Extension Service (and in the case of blueberries, also with the Pomology Department) with the local Farm Advisor's Office taking the main responsibility for the field work.

Christmas tree variety trial. Only three varieties continued to be watched as having any possible merit.

Douglas fir is the most promising of them all. By December they were 2½'-5' and dark green in color with light green new growth on some plants. Shape was fair to good. They had much thicker, more dense foliage than most mountain grown trees.

Scotts pine was 3'-4' tall with fair to good shape but with the undesirable characteristic winter yellowing. Not yet ready for market.

A 9½' redwood was cut 2' above the ground for a Christmas tree. The cut tree, in common with the others had excellent shape and density. An immediate drawback was the prickliness of the foliage. When set up in a house it dried rapidly and the branchlets became very brittle causing a large amount of "leaf" fall. Delta grown redwoods are not likely to compete successfully against other, more usual Christmas tree varieties.

Blueberries. A red leaf condition and general unthriftiness of the plants was not alleviated by any of last year's soil treatments. After observing the bushes throughout the summer and determining that salty soil was not the problem, it began to look like the plants were simply suffering from too

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INTER-ROW PLANTING - A ONE SHEET ANSWER

by

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John P. Underhill, Farm Advisor
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Inter-row planting is a method for reducing wind erosion in ridged fields of white asparagus. It consists of the growing of fast growing small grains in narrow strips between the ridged asparagus rows. Although not completely perfected, it has been developed to the point, over the past 4 years, where many growers, conscientiously interested in the prevention of costly wind erosion in their asparagus can use this method with reasonable assurance of success and with no serious problems developing. The principal points still to be worked out from the research standpoint are the search for grains more suited to interplanting than barley, and more complete measurements on wind erosion control. Inter-row planting, when done properly and grown to adequate height, has proven to be highly effective in wind erosion control, having nearly completely eliminated erosion and dust in cross-wind (north-south) plantings, while eliminating up to 5/6 of the dust from plantings parallel to the wind. The purpose of this sheet is to give you in brief form, the more important information and instructions relating to inter-row planting as we know them today. Close adherence to these suggestions should enable you to effectively utilize inter-row planting, in its present state of development, with a minimum of cost and problems to the grower.

What grains to use. Although numerous grains are still under study, California Mariout barley appears to be the most suitable all-around grain that is readily available. Onas 53 wheat will stay green longer and should prove superior to barley in several respects if planted not later than April 15 to compensate for its somewhat slower growth. Mixtures of barley and wheat may be more suitable than either alone but this has not yet been tested. Arivat barley has been successfully used in the field for very early plantings (February and March). Plot tests indicate that for April plantings, although probably suitable, both Arivat and Rojo barleys appear inferior to California Mariout. Other barleys and wheats tested (including Golden Mariout) have one or more characteristics making them less suitable than the grains listed above.

Planting date. The planting date is always a compromise between that for maximum growth of the grain (say, mid March to the first part of April) and that for greatest convenience in asparagus management (after all ridging and working of centers has been accomplished) with all but four openers removed (2 pair spaced at 8' centers) and an ordinary fertilizer drill. Several special home-made rigs have been built up from standard grain drill or fertilizer distributor parts. Some of these are available on loan and may be obtained by contacting this office.

Width of grain strip. The strips may consist of 1, 2, or 3 drilled rows, 6" spacing. The choice is not entirely arbitrary. Although more rows per strip with the same seeding rate per asparagus acre will give better grain growth, particularly in dry years, there are other considerations. Because of the narrowness of centers between beds on 7' and 7½' plantings, a single drilled row would be the normal practice with 2 rows being used only when there is ample room in the centers and the soil is on the dry side. With 8' beds, 3 rows can be used if the beds are young and the centers 2½' to 3' wide. However, with older, more shallow plantings where ridges tend to be high and centers narrow, 1 or 2 drilled rows are much to be preferred. The narrower row gives cutters more room to walk and makes later re-ridgings easier and with less likelihood of cutting out some

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strips between the ridged asparagus rows. Although not completely perfected, it has been developed to the point, over the past 4 years, where many growers, conscientiously interested in the prevention of costly wind erosion in their asparagus can use this method with reasonable assurance of success and with no serious problems developing. The principal points still to be worked out from the research standpoint are the search for grains more suited to interplanting than barley, and more complete measurements on wind erosion control. Inter-row planting, when done properly and grown to adequate height, has proven to be highly effective in wind erosion control, having nearly completely eliminated erosion and dust in cross-wind (north-south) plantings, while eliminating up to 5/6 of the dust from plantings parallel to the wind. The purpose of this sheet is to give you in brief form, the more important information and instructions relating to inter-row planting as we know them today. Close adherence to these suggestions should enable you to effectively utilize inter-row planting, in its present state of development, with a minimum of cost and problems to the grower.

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Planting date. The planting date is always a compromise between that for maximum growth of the grain (say, mid March to the first part of April) and that for greatest convenience in asparagus management (after all ridging and working of centers has been accomplished) In practice, every effort should be made to get the grain in by mid April or as soon thereafter as possible, in no case later than the first week in May which is already getting so late as to make inter-row planting only partially effective. The later planting also runs the risk of insufficient soil moisture.

Types of planters used. Many types of planters have been successfully used. Of particular note were a 10' standard (not press wheel) grain drill with all but four openers removed (2 pair spaced at 8' centers) and an ordinary fertilizer drill. Several special home-made rigs have been built up from standard grain drill or fertilizer distributor parts. Some of these are available on loan and may be obtained by contacting this office.

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Seeding rates. Seeding rates are higher than for normal grain planted this time of year in order that a sufficiently dense stand for windbreak action may be obtained. Excessive rates should be avoided, however, because they are not only costly and wasteful of seed, they can cause excessive trash between asparagus rows during summer fern and might result in serious volunteer problems the following winter.

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Ten to 20 lbs. of barley per asparagus acre is the normal range. More than 20 lbs. per asparagus acre would be considered excessive. Rates in excess of 150 lbs. barley per planted acre (or 100 lbs. if using 3 drilled rows per strip) should be avoided.

Depth of planting. Depth of planting depends on the moisture status of the soil. The main thing is to get it amply deep into moisture. This is because the main, sustaining root system comes out above the seed and if the soil is dry above the seed, this root system will not develop. The seed should go at least 1" into moisture and should be at least 2" deep. Depth of planting much more than 4" may weaken the plant. Associated with the depth of planting is the need for an adequate seed bed. Hard, compacted centers will not produce good growth and should be loosened by chiseling or some other method before planting. Most centers, however, are sufficiently loose not to require this extra operation.

Weed control in grain strips. Weed control has not usually been found to be necessary. However, 2,4-D spray has been successful in combating weeds in the grain strips where necessary. It will not control nutgrass or other grassy weeds. A spray rig using one or two nozzles over the barley strip only has proved satisfactory. In order not to damage the grain, spraying should only be done after the grain is 6"-8" high and stooling out but before it is in boot. The County Agricultural Commissioner should be consulted for the necessary permit to use and obtain 2,4-D.

Winter volunteer. Since the barley grows to maturity by the end of the asparagus season (Onas 53 wheat is better in this respect, taking longer to mature), there is the possibility that barley may volunteer in the asparagus field the following late fall and winter. In actual practice, serious volunteering of barley has occurred only when planting has greatly exceeded the recommended rates. In most cases the light volunteering that does occur, is controlled by normal weed control cultivations. If heavy volunteering should occur, discing should be done in early winter (late November, early December) before the ground is thoroughly wet and while there are still some sunny, drying days. Discing is not very satisfactory in killing volunteer barley during the later, wet winter months. Asparagus field flooding seems to give volunteer control.

Cost. Cost of inter-row planting varies widely depending mostly on whether spraying for weed control is necessary and whether extra discings for winter volunteer are needed. Except for any necessary weed or volunteer control, only two operations are necessary, planting and discing under. Costs appear to normally run from $2.00 to $5.00 per acre.

Federal cost share. For several years now, the Federal Government has approved inter-row planting as a soil conservation measure. It will pay $2.00 per acre for inter-row planting through its Agricultural Stabilization and Conservation program. Be sure to apply for this benefit before planting. Contact the San Joaquin County Agricultural Stabilization and Conservation Committee at 742 East Charter Way, Stockton, or telephone HO 2-5188

A few important do's and dont's:

Do
1) plant immediately after white ridging, prior if possible.
2) plant into adequate seedbed.
3) plant into furrowed out centers if 2nd higher ridging is anticipated.
4) plant straight rows in very center between beds.
5) plant deeply into moisture.

Don't
1) don't plant at excessive rates or volunteer problems may become serious.
2) don't plant 2 or 3 rows per strip on 7' or 7½' beds or on old, shallow 8' plantings.

In conclusion, we wish to emphasize the importance and need for care and thoughtfulness if inter-row planting is to be successful and of real benefit to you. Excessive seeding rates may result in excessive winter volunteering, crooked or off-center strips may result in trash in beds during re-ridgings and some loss of inter-row, improper or late planting may result in poor growth, ineffective in erosion control.

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Since a brief paper such as this cannot fully cover such a subject, any questions or requests for help in your inter-row planting problems will be welcomed by the authors who can be contacted at 145 South American Street, Stockton telephone HO 6-2581.

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A. B. Carlton
Davis, Soils and P. M.

January 19, 1960

much heat. This was partially confirmed when one of the cooperators interplanted his berries with corn, shading them entirely from the sun. There was no indication of the adverse symptoms which the plants had shown in previous years. This hypothesis is to be tested by the use of artificial shade in the 1960 season.

Irrigated pasture. The 1959 work consisted of advisory work by the Farm Advisor on cattle management problems in the delta and the testing of two pastures for copper and molybdenum. They had molybdenum contents of 12 to 20 ppm in legumes, with copper running 12 to 15 ppm. Copper in the grasses was higher with 12 to 34 ppm. Cattle on pasture with 12-14.5 ppm Mo in legumes, 1 ppm Mo in grasses, and with Cu running 15-34 ppm seemed to respond to Cu-glycinate treatment by becoming more thrifty and by coat color turning from brownish to black.

Subsidence

A measurement of differential subsidence was reported in the 1957 report on page 79. The calculated yearly rate of differential subsidence was based on a 20-year period. It was determined in 1959 that the railroad wye used for measurement was actually begun and completed in 1927. The calculations should therefore have been based on a 30-year period. The corrected calculations would then be 0.57 inch per year differential subsidence or 16% of the total subsidence (based on the rate of subsidence of Lower Jones, Mildred, and Bacon Island - 3½" per year). This 0.57 inch per year must include all wind erosion and whatever increased oxidation might be caused as a result of working the ground for crop production.

Soil Temperature Measurements

Soil temperature measurements begun in 1958 and described on p. 113 were continued. Yearly highs of 80°F. at 12" and 102°F. at 4" were recorded. Lows were 52°F. at 12" and 41°F. at 4".

Soil temperature measurements were also made under clear plastic film mulch to determine the effect of such film on organic soil temperature, particularly at depths to 12". If early spring soil temperatures can be raised economically it is possible that asparagus can be started earlier in the spring at a time when premium prices prevail. The limited work in 1959 shows this to be a distinct possibility. When 2 mil clear polyethylene sheeting was applied to the ground and sealed around the edges on February 17, a distinct warming of the soil was recorded. At the 12" depth, the plastic treated plot gained 4°F. over the control plot in two weeks and 7°F. in three weeks. While the control plot rose 6°F. at the 12" depth during the first three weeks, the plastic mulched plot rose 13°F. At the 4" depth, temperature increases were 10°F. over control in two weeks and 13°F. in three weeks. The plastic sheet was removed on March 13 and by April first, temperatures at the 12" depth were again the same in the ex-plastic mulch plot and adjacent control.

Increases of the same order were obtained in a similar experiment begun at the end of June and carried into August. The greatest increase in temperature at 12" depth was 11°F. which occurred after five weeks.

It is intended that the study of plastic sheeting for soil heating will be continued and extended in 1960, perhaps with some limited field trials in asparagus.